Complexity, Dynamism, and Agency: How Can Dialectical Biology Inform Geography?

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Abstract

Dialectical approaches, variously interpreted, have been advocated for by geographers for several decades. At the same time, critical environmental geography has recently become dominated by vital materialist strands of thought, the advocates of which have sometimes framed their own work in opposition to dialectics. Critics perceive two major problems with a dialectical framework; that it cements a nature-society dualism and that it insufficiently accounts for the agency or vitality of non-human life. This paper seeks to address these criticisms by engaging with work by biologists who have been influenced by dialectical ideas. I outline two examples, Richard Lewontin and Richard Levins' understanding of the way organism and environment mutually construct each other and research by Ivette Perfecto and John Vandermeer that offers a non-dualist approach to wildlife conservation in agricultural ecosystems. The article discusses some of the ways in which these understandings might inform contemporary debates in political ecology.

Keywords

dialectics, new materialisms, biology, non-human agency, niche construction, novel ecosystems

In a 2015 paper in *Antipode*, Shannon Brincat and Damian Gerber (2015) make the case for a dialectical approach to contemporary environmental geography. For Brincat and Gerber this

is not just desirable but necessary: “it is only in moving toward a dialectical account of the totality…that we can begin to grapple with the accelerating ecological crises of the present” (2015:873). For these authors, nature should no longer be seen as external to human history; capitalism and its crises are inherently ecological. And, they argue, seeing “society in nature” as a totality or dynamic whole is a key aspect of dialectical thought. This stress on the dynamism of socio-natural systems is central to their argument. Dialectical thinking, they say, will enable us to grasp the potential for change inherent in the present; multiple and pervasive ecological crises will “shatter the illusion of the permanency of the capitalist world order” (Brincat and Gerber 2015:890).

Brincat and Gerber are not the only theorists who have referred to their work as dialectical. According to Castree (1996) dialectics, variously interpreted, has proved appealing to geographers since the late 1970s and continues to be discussed and debated. For example, Andy Merrifield (1993) has developed a dialectical approach within urban theory. Similarly, Edward Soja (1980) referred to his understanding of the way societies and spaces are mutually constitutive as a “socio-spatial dialectic”. Tyner and Inwood (2014) attempt to develop a dialectics of violence and a special issue on dialectics of *Environment and Planning A* featured various contributions from geographers (Dixon et al. 2008).

However, this article will draw on the ideas of a different group of dialectical thinkers, a small group of self-identifying dialectical biologists. Although the work of these biologists has sometimes been mentioned by social scientists, it has been underutilised within critical environmental geography, a field that has recently come to be dominated by a range of approaches collectively referred to here as new materialism or vital materialism. Bruce Braun (2015:1-2) describes this “diverse and increasingly well known” body of literature and notes its non-dualistic approach and emphasis on the inventiveness, vitality and indeterminacy of natural processes. This article argues that the debate between those adhering to dialectical and vital materialist approaches respectively has been framed by false antitheses. It aims to add clarity to these debates by highlighting a tradition of dialectical thought concerned with complexity, dynamism and agency, concerns that are also associated with new materialist thought. This calls into question some of the criticisms levelled at dialectics, specifically that it insufficiently accounts for the agency or vitality of non-human life.

The following sections will discuss some of the ways in which dialectics has been understood within geography before examining the debates between its advocates and those adhering to vital materialist approaches. The article then goes on to assess the theoretical contribution made by the dialectical biologists within their own discipline. This research is

based on interviews I carried out with several of these biologists as well as engagements with their written work.

Why Dialectics?

For Bertell Ollman, dialectics is "a way of thinking about the relations and processes in the world, and a method for studying them" (2014:573). Dialectics involves viewing reality as consisting of multiple *processes* that undergo continual change and are constantly relating to each other. It therefore defies the common sense view that reality consists of separate *things* that are more or less discrete. Ollman argues that Marx employed a dialectical mode of thought in order to understand capitalism and that dialectics continues to be one of the distinctive contributions of Marxist theory. Marx's collaborator Friedrich Engels seems to have been sympathetic to this interpretation of dialectics, stating that: "The world is not to be comprehended as a complex of ready-made things, but as a complex of processes, in which the things…go through an uninterrupted change of coming into being and passing away" (1947:52). One of the major distinguishing features of this interpretation is that it is a philosophy of internal relations as opposed to one of external relations. The latter "holds that reality consists of things…with boundaries that are distinct and relatively stable, which can undergo changes and get into relations" (Ollman 2014:574). In contrast, for Ollman reality is rather seen as fundamentally constituted by relations; a thing would not be what it is without the relations in which it exists. Ollman points out that various thinkers from Heraclitus to Hegel have favoured similar philosophies. Importantly, for Ollman his approach is simultaneously an ontology and an epistemology, a statement about the nature of reality as well as about how we might understand that reality. Ontology and epistemology are themselves internally related; ways of understanding the world must also relate to the way the world is (Ollman 2014:574).

One of the best known endorsements for such an approach within geography comes from David Harvey (1996) in *Justice, Nature, and the Geography of Difference*. Harvey defines dialectics in opposition to Cartesian reductionism. Whereas a Cartesian thinker might assume that reality can be understood by breaking it down into its constituent elements (each with its own independent properties) and studying each in isolation, a dialectician starts from the premise that the parts of any system cannot be understood without taking account of the whole within which they operate. Critics might argue here that it is impossible for a thinker to grasp the whole of reality at once; that it is therefore necessary to understand the world as composed of bounded entities to prevent "the study of anything spilling over into everything"

(Ollman 2014:574). Ollman counters this by saying that Marx employed a process of abstraction, bringing one aspect of a complex system into view momentarily in order to focus on it from a particular vantage point. But this does not imply treating that particular aspect as operating distinctly from other aspects of a totality (Ollman 2003, 2014).

Things, as they are constituted by relations, exist "in a state of ongoing becoming…never the same thing at any time" (Robbins 2012:94). Therefore, dialectics allows the thinker to grasp something about a world that is constantly in motion (Ollman 2003), it places the emphasis on processes and flows rather than form and fixity allowing for an understanding of the processes driving change, why things that might appear solid and fixed come into being, as well as what forces pull them apart. Such an approach sees dynamism as an inherent property of things rather than external to them and, as a methodology, it treats dynamism as central to analysis rather than peripheral to it.

Related to this focus on dynamism, dialectics differs from some other approaches in that it is unapologetically political. Marx's project for much of his life was to use such a methodology to analyse the capitalist system. Marx didn't merely understand the system as it existed in his time, he set out to understand the processes by which it had come about and the direction in which it was heading (Ollman 2014). In one of his few accounts of his methodology, in the afterword to the second German edition of *Capital*, Marx (1976:103) stated that the dialectical method "regards every historically developed social form as in fluid movement, and therefore takes into account its transient nature not less than its momentary existence…and is in its essence critical and revolutionary". This sentiment is evident in Brincat and Gerber's (2015) references to illusions in the permanency of the capitalist system. They agree that dialectics allows its adherents to critique specifically capitalist socio-natural relations, rather than naturalising them: such approaches treat the current state of things as always open to change, and seek out the potential for such change within the conditions of the present.

Brincat and Gerber are concerned in their article to apply a dialectical understanding to questions of "nature" and the environment. The following section this article will briefly recount some of the uses of dialectics in environmental debates before addressing the challenge posed to it by new/vital materialist approaches. It is by now well known that Marx and Engels took an interest in the natural sciences and, it seems, saw their approach as relevant to understanding the "natural" world as well as relations between humans (Foster 2000). Likewise, in their writings on dialectics Ollman and Harvey both make little attempt to distinguish between "nature" and "society". When the things of the world are dissolved into

the results of an ever-shifting ensemble of multiple processes it makes little sense to attempt to separate those things that are "social" from those that are "natural". But, as Brincat and Gerber (2015:872-875) see it, Marxism in the 20th century had lacked an appreciation of (what they call) the "affinity" between humanity and nature; for them nature needs to be reintegrated into dialectics in order to recover a more naturalistic Marxism.

Brincat and Gerber see dialectics as offering a way round dualistic approaches to environmental politics; in other words those that rely on a conceptual division of society and nature. Readers of *Antipode* will no doubt be familiar with such critiques of nature-society dualisms. One of the major reasons why dualist approaches are seen as politically problematic is that they tend to treat human society as impacting *on* nature rather than acting *as a part of* nature with the logical corollary that humanity must collectively scale back its impact. Such an approach avoids entirely the discussion of the historically specific ways in which nature is produced–or in whose interests it is produced–that its critics say is needed (Loftus 2012:xxii). It therefore also precludes discussion of the wide-ranging societal changes needed to address today's environmental problems. Philosophical dualism has also been linked to the association of nature with wilderness, erasing the history of human habitation of so-called "wilderness" areas and at the same time treating urban areas as unnatural and as beyond the remit of environmental social movements (Cronon 1995). Jason Moore (2015:2-6) sees the notion of nature as external to human society as an ideological inheritance from the origins of capitalism. For Moore, dualism as an ideology makes natures more commensurable to capitalist appropriation, and the philosophical separation of humanity and nature in Western thought also underlines other dualisms including orientalism and binary understandings of gender relations. Furthermore, as Neil Smith (2008) pointed out, the view that nature is external to human society goes hand in hand with the assumption that nature is itself fixed or static. As we shall see such a position is at odds with biological reality. Understanding biological systems as existing in a state of flux has been central to dialectical biology, as has the project of accounting for processes that, rather than being "social" or "natural" are fundamentally socio-natural.

Several authors have attempted non-dualist dialectical interpretations of environmental issues. For example, Alex Loftus (2012) takes "inspiration from Marx's dialectical approach to understanding the world" for his project of rethinking environmental politics. As Loftus argues, an approach drawing on Marxist dialectics can provide a framework "that is flexible enough to capture the interaction of what are normally conceived as separate elements: the natural and the social, the historical and the geographical" (Loftus

2012:xvii). Rather than being premised on a dialectical interaction between two separate elements–such as nature and society–such an approach calls into question the historical processes through which these elements came to be seen as separate.

Moore (2015:46), in *Capitalism in the Web of Life*, likewise employs what he describes as a dialectical approach and refers to dialectical biology, mentioning Richard Levins and Richard Lewontin (1985) and their book *The Dialectical Biologist* although he doesn't discuss their contribution to biology in detail. For Moore (2015), a dialectical methodology is necessary to understand the ways in which capitalism's historical development has taken place *through* nature rather than in opposition to it.[i] Harvey (1996) also draws on Levins and Lewontin's work in setting out his own explanation of dialectical methodology, and Ted Benton (1991) refers to Lewontin while calling for further engagement on the part of sociologists with non-reductionist biology.

In a series of recent interventions John Bellamy Foster has asserted the importance of a dialectics of nature–a theory of dynamics, complexity and transformation–to his classical Marxist approach. For Foster, nature and society form a dynamic but differentiated whole, with the relationship between the two mediated by human labour. Foster differentiates his approach from both Ollman and Moore, referring to external relations *between* human societies and their natural environments as well as internal relations (Foster and Clark 2016; see also Foster 2016).

Foster's colleagues Brett Clark and Richard York (2005a) have similarly used the word "dialectical" to refer to the way a human society relates to its external environment. Intriguingly they see this relationship as analogous to biologist Lewontin's ideas about how living organisms relate to their own immediate environments which will be further discussed below. For Clark and York, dialectical thinking has implications for environmental problems more generally in that it avoids both mechanistic or idealist understandings. The former, they argue, treats nature as if it is like a machine, with deterministic properties. This is readily commensurable with capitalist production, for example by valuing nature as ecosystem services, as it implies that any problem can be overcome by human manipulation with predictable and measurable effects. Idealism, by contrast, assumes that nature existed in a state of balance or harmony before industrialized human societies interfered with it. This approach fails to take a materialist approach to human societies, treating them simply as an external threat to an otherwise stable natural world (Clark and York 2005b). These approaches are very different, but both are ahistorical. Both tend towards seeing "nature" as external to human society, whether as a source of inputs or as a balanced and harmonious

realm that humans disrupt. In contrast, Clark and York suggest that dialectical thinking is necessary to take into account the ways in which human societies have developed in relation to a changing natural environment (Clark and York 2005b).

In *Lawn People*, Paul Robbins (2007) adopts some of the same concerns as Clark and York. Although Robbins does not use the word "dialectical" in this work he points out how grassy environments have evolved alongside human civilisations throughout history with humans spreading grass species around North America. As well as lawns being cultivated by people, the needs of lawns continues to produce turfgrass subjects of the people who manage them. Far from being simply an expression of culture, the lawn itself plays an active role in the relationship between lawn and owner. Robbins later referred to dialectics as a key (if unacknowledged) methodological influence within political ecology by including a section on "human-non-human dialectics" in his critical introduction to the sub-discipline (Robbins 2012). To conclude, dialectics offers an ontology that appears to avoid problematic society-nature dualisms, is fundamentally relational, seeks to understand a totality but employs a method (abstraction) for dealing with particular aspects of that totality in turn, and has at its core the idea that socio-natural relations can be changed.

New/Vital Materialisms

However, while dialectics continues to be debated among environmental thinkers, particularly those influenced by Marxism, new materialist ideas have grown in popularity, including in geography (Braun 2015). The term "new materialist" covers a range of sometimes divergent theories. However, both Braun and Diana Coole (2013) say that this set of approaches have several characteristics in common making it possible to lump them together.

Firstly, new materialism represents a renewed engagement with the material properties of things themselves and often on matter's supposed vitality, creativity and capacity to surprise: "matter is alive with the creative potential of endless evolutions and innovations" (Kearnes 2006:67). For example, in *Vibrant Matter*, Jane Bennett (2009:58-60) reflects on the properties of metals, describing their crystalline structure and suggesting that these have a capacity to transform themselves as cracks spread through their structure as well as being able to be transformed by human agency. Traditional forms of vitalism have proposed the existence of a vital force ("elan vital") that animates matter otherwise considered inert. By contrast, both Bennett and Elizabeth Grosz (2011:34), in *Becoming Undone*, make clear that they see liveliness as emerging and developing *from* matter rather

than encountering it as an *external* force: "life is not suffused of a special substance, soul, mind, or consciousness that separates it from materiality. It is the vital indeterminacy of the material world that enables life and that life exploits for its own self-elaboration".

Secondly, new materialism develops an ontology of becoming or a process-based ontology. Thus, new materialists have turned their attention to the processes that constitute things, proposing that everything is in a continual process of becoming: "socio-ecological systems" have a "never exhausted potential to assume other forms" (Braun 2015:3).

Thirdly, new materialist accounts have expanded the scope of what counts as "agency", often seeing non-humans as political ecological actors. Such work is a decisive shift away from anthropocentrism: approaches that see humans alone as possessing agency or that make rational human action the yard-stick against which an entity's capacity to exhibit agency is measured. For example William Connolly (2013) opposes seeing human subjectivity as the "fundamental ground of things". For Jamie Lorimer (2007), vital materialist thinking is influenced by the understanding of agency developed under the banner of actor-network theory. Actor-network theory (ANT), perhaps most closely associated with Bruno Latour (2005), is premised on the idea that entities, which might be human or non-human, come together in networks to make things happen. Agency, rather than being a possession of a particular element in a network, arises as a result of the way these elements relate to each other (see also Castree 2002).

Finally, and related to the other three points, new materialist ontologies preclude seeing the world as fundamentally divisible into "social" and "natural" realms. They achieve this by allowing for non-human entities–both living and non-living–to be considered as actors and therefore endowed with some of the capacities conventionally reserved for humans and/or by drawing attention to the inhuman forces that constitute humans themselves. The fact that all humans have a microbiome, a community of microorganisms living on and inside us, is just one example of how entangled human lives are with those of non-human species (see Gilbert et al. 2012). This is often invoked to challenge individualistic assumptions about the human (see, for example, Connolly 2013).

New materialist accounts attempt to overcome some of the perceived inadequacies of earlier forms of thought. In particular, the proliferation of such approaches can be seen as a reaction to the dominance of accounts focussing on language, discourse and representation. A "cultural turn", that, it is argued, tended to marginalise discussions of the material (Coole and Frost 2010).

But the rise of new materialisms can also be seen as a challenge to other materialisms, including Marxist dialectics. For some of its critics, dialectical thinking is unhelpfully predicated on the prior establishment of two distinct and opposing entities that come to relate to each other. In other words it is criticised for precisely the reliance on external relations that Ollman's dialectics explicitly rejects. That critics can assume this is hardly surprising as dialectics is often defined as "the perpetual resolution of binary opposites" (see, for example, Derek Gregory's [2009:157] entry in the *Dictionary of Human Geography*). This suggests a framework whereby a thesis encounters its opposing antithesis and the two are resolved to produce a new synthesis (which will then encounter a further antithesis *ad infinitum*). Therefore, such an approach can be seen to treat society and nature as two separate realms that come to relate in a reciprocal manner: society acts on nature and nature acts back. This has led Sarah Whatmore (1999:25) to dismiss dialectics as insufficient for grasping socio-natural phenomena that are fundamentally hybrid as "far from challenging this *a priori* categorization of the things of the world, dialectics can be seen to raise its binary logic to the level of a contradiction and engine of history". However, Noel Castree (2002:115), referring to Whatmore's claim, says that her view is "not based on any in-depth analysis of Marxian theorisations of the nature-society interface". Eric Sheppard (2008:2604), referring to Gregory's definition of dialectics as a perpetual resolution of binary opposites, has argued that this interpretation does not reflect the way dialectics is generally utilised in practice.

It should be clear from the brief outline above that many of the tenets of the new materialism, particularly its emphasis on processes rather than fixity and its refusal to accept nature-society binaries, are similarly subscribed to by many dialectical thinkers, particularly those influenced by the philosophy of internal relations. As Kirsch and Mitchell (2004:689) put it: "One of the foundational moves of Marxist theory, like that of ANT, was a radical shift to a relational ontology, a world of relations and processes and not things-in-themselves". Noel Castree (2002) has therefore argued that "false antitheses" have framed the encounter between environmental Marxism and alternative theories that call for a recognition of multiple forms of agency. [ii] While maintaining that ecological Marxism has made an important contribution to critiquing specifically capitalist environmental relations, he argues that it can be synthesised with theories that complicate environmental politics by acknowledging the role of multiple actors.

However, Kirsch and Mitchell (2004), while in agreement with much of Castree's (2002) argument, caution that there are still substantial differences between Marxism and approaches such as ANT, despite efforts to reconcile them. In particular they say that ANT

would have us ignore problems of causality or the directedness of social relations. For example the overriding role of competition between capitals in shaping what happens in the workplace is downplayed in favour of an approach whereby social relations in the workplace are seen as the outcome of relationships between people, machines, commodities, and things (Kirsch and Mitchell 2004:700-701). This leaves ANT oddly "politically inert", with some of its advocates even averse to making some of the normative judgements that are so central to dialectical thinking (Kirsch and Mitchell 2004:694-695). Likewise, Tyner and Inwood (2014:774) see dialectics, because is about processes rather than things, as going beyond surface appearances in order to get at "underlying" social relations.

There is still, as Loftus (2012:4) puts it, a "muted standoff" between those who advocate Marxist and new materialist approaches. Dialectics has also been criticised from a slightly different perspective–for its perceived tendency to foreground human agency at the expense of recognising the role of non-humans, and for giving insufficient attention to the materiality of non-human nature as well as that of the human body (Lorimer 2013). Lorimer, for whom dialectics lies "at the heart of Marxist geography" (2013:127), contends that a version of vital materialism is much more able to account for a diverse range of actors, for example in his own research into the way non-human charisma shapes the priorities of wildlife conservation (Lorimer 2015). Neil Smith's (2008) production of nature thesis attracts particular criticism here. With its explicit focus on the role of *human* labour in producing natures, it is seen as tending to "minimize the influence of nature as a material force" (Boyd et al. 2001:557; see also and Loftus 2012:13-16; Lorimer 2013). Lorimer intriguingly also suggests that Marxist thinkers have downplayed discussions of non-human agency due to a "residual Marxist antipathy...to discussions of the environment as a limit" (2013:127).

Recent work on lively commodities has tried to bridge the divide between emerging work on non-human agency and materiality and Marxian concepts of labour, value and commodification. For example, Maan Barua (2016) demonstrates how, in encounters between humans and large animals, for example between tourists and elephants, the physical features of the animals contributes towards what, following Donna Haraway (2008), he calls "encounter value". The intention here is to move beyond the notion, common in political economy, that non-humans are a mere resource or a substrate on which human labour occurs towards seeing animals themselves as active participants in a process of capital accumulation. Boyd et al. (2001) have utilised Marx's distinction between formal and real subsumption of labour, arguing that this distinction applies to the ways in which natural processes are incorporated into industrial production as well as to human labour.

Of the two criticisms of dialectics discussed above, the first–that it relies on a binary logic–is not true of the dialectical approaches outlined so far. To the best of my knowledge, none of the advocates of dialectics cited above are referring to a relation between only two types of thing. The second–that it plays down non-human agency and materiality–poses more of a challenge to Marxist discussions of nature. However, I argue that far from rejecting issues of materiality and non-human agency, these are actually major concerns within one area of Marxist thought, the dialectical approach to biology. Therefore it is useful to engage with the way in which biologists have developed an understanding of dialectics within their own discipline in order to understand how their ideas might help rethink political ecology.

As Braun (2015:3) points out, works in the new materialist tradition often make use of concepts from the natural sciences, including biology. This is "not only justifiable but also necessary" for those who reject dualistic views of society and nature. But, for Braun, there is a persistent problem with scientism in some of the literature, including a tacit assumption that science "speaks in one voice" and the neglect of sharp theoretical differences *within* the natural sciences. Scientism, seeing scientific knowledge as neutral information on which social scientists can build their ideas, is unhelpful for a critical political ecology. Certainly the existence of a group of biologists who take their influence from Marx and Engels demonstrates Braun's point that biologists are far from united in their ideological worldview. But, due to misunderstandings and sometimes hostility towards dialectical thought on the part of some within the new materialist tradition, the contribution of this group of biologists has yet to be fully explored.

In summary, new/vital materialist approaches have contributed much to discussions of non-human agency in environmental geography and sparked a welcome engagement with the natural sciences. However, critics have sometimes found these approaches politically inert. Conversely, while dialectics is more expressly political, its advocates have made relatively little attempt to engage with the natural sciences and a need to develop a more naturalistic dialectics has been identified. In the sections that follow, this article will attempt to speak to both sides of this debate by outlining two case studies of dialectical approaches to biology: the theory of niche construction and the approach to wildlife in agricultural ecosystems taken by a group of Marxist ecologists.

Levins, Lewontin, and Niche Construction Theory

Perhaps the best known of the small group of self-identifying dialectical biologists are Richard Levins and Richard Lewontin. Their 1985 book *The Dialectical Biologist* influenced

future generations of left-wing biologists in the US and worldwide. Levins and Lewontin have combined distinguished academic careers (both becoming professors at Harvard) with political activism. They were involved in Science for the People, an organisation that was active from the late 1960s until the 1980s and supported numerous causes including opposition to the Vietnam War, support for the Black Panther Party, women's liberation, and research work with trade unions. The group published widely including in a bimonthly magazine–the organisation had established around ten chapters across the US by 1970 (Moore 2013).

One of Levins' and Lewontin's key contributions to biology is their discussion of the relationship between organism and environment (Levins and Lewontin 1985, 2007; Lewontin 1982); their ideas on this were a major influence on the theory of niche construction "the process of organism-driven environmental modification" (Odling-Smee et al. 2003), a theory that continues to gather enthusiastic advocates among biologists. For Lewontin, organisms play an active role in constructing their environments. Rather than simply encountering an environment, they "actively change and construct the world in which they live" (quoted in Odling-Smee et al. 2003). This process of making an environment involves the organism acting:

> They take bits and pieces of things that are out there already but to make them into an environment means to collect them together, to burrow in them, to chew them up, to do all kinds of things. (Interview, 16 April 2014)

Lewontin thereby emphasizes what might be referred to as the agency of living things in changing the world around them, a view shared by Steven and Hilary Rose (2010), who note that "far from passively responding to a fixed environment, organisms…modify their environments".

For some of the biologists I spoke to, the idea that organisms make their environments recalls Marx's famous saying that people "make their own history, but they do not make it as they please".[iii] Lewontin has also referred to the organism as the subject and object of evolution, echoing the view of Hungarian Marxist Georg Lukács (1971:19) that people are "simultaneously the subject and object of the socio-historical process". But these ideas have now spread beyond the small group of biologists with an interest in Marxism. Many of those biologists working on niche construction would not use the term dialectical or claim to be influenced by Marx.[iv] Nevertheless, for Lewontin, widely thought of as an originator of the

idea, niche construction is “the best example I can think of of a dialectical approach to biology” (Interview, 16 April 2014).

Of course, those who point out that organisms construct their environments are making what seems an obvious point. It is well known that beavers change their immediate surroundings by building dams; birds, ants and various other animals build nests; plants change the composition of the soil (Odling-Smee et al. 2003). Humans can also be thought of as niche constructors, modifying our own environments albeit on a vast scale. Indeed, changing the composition of the external environment, even by taking in nutrients and expelling waste products, is fundamental to what all living things do (Levins and Lewontin 2007:33). If all these biologists were saying is that living things have an effect on the world around them they would be saying nothing new. However, for Levins and Lewontin an emphasis on the active role of organisms themselves has allowed them to question assumptions about what is meant by “environment” and also to challenge orthodoxies within evolutionary theory.

In ecology, the world in which organisms (be they humans, other animals, viruses, fungi, plants, etc.) live is referred to as their niche. However, the niche is not to be understood simply as a place–such as a rainforest, a rock pool, or the soil in a field–these are more properly called habitats. A niche, by contrast, is a set of conditions that an organism encounters that is relevant to that organism, it is “used to describe *how*, rather than just where, an organism lives” (Begon et al. 2006:31; Preston 2003:47-72). For example a humpback whale might only be able to tolerate temperatures within a certain range, salinity within a certain range, a certain minimum amount of food, etc. This way of thinking implicitly acknowledges that a niche does not exist without the organism that lives in it. If there was no such thing as a humpback whale, the habitat (the ocean) would still exist but it would make little sense to refer to the niche of such a creature. Nevertheless, biologists have sometimes *argued as if* the niche exists prior to the organism, understanding living things as existing within particular limits that circumscribe what is a suitable environment–the implication being that if something encounters conditions to which it cannot adapt it will not survive. For Lewontin, the assumption that a niche exists prior to an organism is erroneous. Rather, niches are both created and defined by organisms.

For Clark and York (2005a), niche construction theory implies that an organism exists *in a relationship with* an environment and similarly a human society can be thought of as in such a dialectical relationship. These authors do sometimes slip into binaries, referring to a “dialectical interchange *between* the environment and the organism” (Clark and York

2005b:328, emphasis added). However, they also stress that this is a dynamic relationship of mutual transformation rather than simple reciprocal interaction where organism impacts on environment and vice versa.

Levins and Lewontin have sometimes also spoken in terms of reciprocal relationships: "changes within the organism alter the external environment, which in effect then feeds back into the development and metabolism of the organism itself" (2007:83). However, elsewhere they have been more critical of any kind of *a priori* distinction between organism and niche. They have also applied to same logic to "society" and "nature", refusing to delineate these prior to the relations that produce them. For example they have provocatively stated that "one cannot make a sensible environmental politics with the slogan 'save the environment' because, first, 'the' environment does not exist, and second, because every species, not only the human species, is at every moment constructing and destroying the world it inhabits" (Levins and Lewontin 2007:34). In saying that "the environment does not exist" they echo Alex Loftus' (2012:xiv) statement that "there's no such thing as nature" and seem to be in agreement with those social theorists who have questioned the adoption of "the environment" as an object of analysis. Indeed this aspect of Levins' and Lewontin's work has been referred to by Maria Kaika (2005:23) and Erik Swyngedouw (2014). Here Ollman's distinction between external relations and internal relations is useful: Clark and York seem to be, at least in this case, referring to external relations, whereas the dialectical biologists seem also to adopt Ollman's approach based on internal relations by questioning the very prior existence of "the environment".[v]

Niche construction is seen by its advocates as a "neglected process" in evolutionary biology as well as being relevant in ecology (Odling-Smee et al. 2003).[vi] The ability of organisms to construct a niche has often been thought of as a *consequence* of evolution. So a species has evolved particular characteristics over many thousands of generations and, once acquired, those characteristics allow it to modify its environment. At the same time in Darwinian natural selection the arrow of causation goes in the other direction, from environment to organism. As Darwin observed, a population of organisms will tend to vary in their characteristics. Those with traits most suited to their environment will be more likely to survive and reproduce therefore passing on their genes to future generations (survival of the fittest really means survival of those most suited to the environment).

Levins and Lewontin (2007) note that modern evolutionary biology has therefore been founded on a strict separation of causal factors with those internal to the organism and those external to it treated as distinct. Two metaphors have become widely accepted and have

come to direct thinking in evolutionary biology. The "trial and error" model assumes that an organism's niche poses problems that it must solve by evolution, while the analogy of "unfolding" common to developmental biology assumes that an organism will develop along a predetermined path under the influence of its genes (Lewontin 1982). Both metaphors, although they have proved useful in biology, are based on externalist logic. Both suggest that organisms passively respond to external forces, whether originating in their environment or in their own genes. Both see the organism as an *object* of evolution. For Levins and Lewontin, this neglects the organism's role as an active *subject* in evolutionary processes (Levins and Lewontin 1985:87-89). This could represent a major force in evolution that had been somewhat overlooked in the past: "We weren't following through and thinking about how that change in the environment then fed back to influence selection…So we tended to think of things in what you might think of as a unidirectional causal way" (Kevin Laland, Interview, 17 December 2015).

The example of the earthworm is often used to demonstrate how niche construction influences evolutionary processes. Worms construct their environment by their digging behaviour, aerating the soil, mixing it with organic matter and facilitating plant growth. Earthworms therefore live in and adapt to an environment that has been substantially altered by many generations of their ancestors (Laland et al. 2004). The niche constructing activities of worms have meant that, as a species, they have exposed themselves to an environment that they have themselves created and this has in turn influenced worm physiology. For example, due to the moist environment they help to create, worms have maintained some of the characteristics of their aquatic relatives. Worms haven't just adapted themselves to life on land; they have adapted their environment to suit their physiology (Odling-Smee et al. 2003). Niche construction theorists argue that the presence of worms–essentially aquatic animals–on land cannot be adequately explained by standard evolutionary theory. They could not survive in their environment without making substantial changes to it (Odling-Smee et al. 2003:374-376).

It should be noted here that niche construction doesn't make the theory of natural selection redundant. It might actually reinforce the theory of natural selection by demonstrating how an organism creates a niche but is simultaneously also an object of what it has created. In standard evolutionary theory organisms are presumed to be well suited to their niche due to natural selection. In niche construction theory a "dynamic interaction" between niche construction and natural selection produces this organism-environment match (Odling-Smee et al. 2013).

It could be argued that real biological systems are too complex and involve too many actors to be adequately accounted for by referring to organisms and environments. Why reduce analysis to the interactions of two types when ecological systems involve multiple interacting humans, animals, plants, microbes, technologies and geological processes? Levins and Lewontin themselves are well aware of this problem. However, like other scientists, they find it impossible not to work with models that describe only particular aspects of a wider system. They differ from mainstream biologists in that they invoke Marx's (and Ollman's) method of abstraction, a way of momentarily bringing one dynamic into view in order to examine it while recognizing that "the truth is the whole" (Levins and Lewontin 2007:186). It is also contended that organism and environment themselves are so entwined that it is no longer justifiable to use organism and environment as points of reference. For example, Gilbert et al. (2012) say that, once the role of the microbiome is acknowledged, animals can no longer be thought of as individuals, a point that has been seized on by some new materialist thinkers. Here, it seems that Levins and Lewontin, if we interpret their work as being built on a philosophy of internal relations, would have little problem with the idea that organism and environment are entwined. For example they also recognize that organisms are effectively "environments" for the other organisms that live on or in them, so what is as an "environment" is defined relationally rather than just there.

In conclusion, the theory of niche construction is predicated on an understanding of the ability of living things (of all species) to act on and change the world around them. It is grounded in an understanding of evolutionary biology that integrates processes internal to the organism and external to it, processes which had once been held to be distinct. It is an attempt to overcome some of the ontological dualisms that have become common in biology.

Novel Ecosystems, Dynamic Interactions

Biologists have drawn attention to the ways in which the activities of different organisms don't just change the environment of the species in question but also change the environments that other organisms are exposed to. As the human species constructs a particularly complex niche then this is perhaps most clear in the case of humans. As environmental geographer Ian Rotherham points out, human environmental modification has created the conditions for some other species to flourish. The warm waters of the River Don, once used for cooling in Sheffield's steel plants, have created the conditions in which forests of figs have grown along the river's banks. The seeds of these Mediterranean plants would not have been able to germinate were it not for human activity (Bramwell 2015). Extending

this insight, Erle Ellis (2015) uses the concept of niche construction in an extensive survey of the world's anthropogenic biomes. This integrates ecological theory with ideas of anthropogenic change in a way that, Ellis argues, would not have been possible by assuming that humans simply adapt to their environment. For some, humans are "champion niche constructors". However, this is not necessarily a case of human exceptionalism. Humans may be able to produce environments with more forethought than other species; but producing environments in general is something all living things do. In the fig tree example, the role of human action is highlighted but there are multiple categories of actor involved including the water and the fig plants. Nevertheless, there is a need to pay closer attention to what dialectical biologists have to say about human-influenced ecosystems, something to which I now turn by discussing the work of Ivette Perfecto and John Vandermeer.

Perfecto and Vandermeer are scientists and political activists who both specialise in the ecology of tropical agro-ecosystems. Both have worked with Levins and were also members of Science for the People. They have a normative preference for small-scale agriculture that uses few or no synthetic pesticides or fertilisers and an interest in shade-grown coffee, i.e. coffee grown alongside tree species (Vandermeer and Perfecto 2012). This type of small-scale farming, adopting agro-ecological principles, is, they argue, best implemented by farmers themselves. Therefore supporting the aims of farmers and their organisations should play a fundamental role in biodiversity conservation in the tropics (Perfecto and Vandermeer 2008). Like Levins and Lewontin, Perfecto and Vandermeer have found it impossible and undesirable to disentangle their scholarship and their activism.

Ecologists like Perfecto and Vandermeer are increasingly interested in what happens in agricultural ecosystems–where human activity has played and continues to play a major role (see Gardner et al. 2009). Ecosystems such as these, characterised by novel combinations of species and arising as a result of human action are sometimes termed novel ecosystems (Hobbs et al. 2006).[vii] And adopting a novel ecosystem approach has led some ecologists to argue that they need to change the way they think. For example Gardner et al. (2009) suggest that ecologists should be more open to the idea that there are shifting baselines at work. They cannot expect that areas of forest are undisturbed environments that act as a baseline against which they can compare the effects of agriculture; the species composition in the forests is also undergoing change due to human activity. For Perfecto and Vandermeer (2008) conservation biology in the tropics has prioritised "charismatic" rainforest environments at the expense of looking at what happens in agricultural systems tending to reinforce the assumption that human activity is simply a threat to pristine environments. Perfecto's and

Vandermeer's work on tropical agro-ecosystems therefore adopts many of the concerns that have animated environmental geography in recent years. For example, they share Lorimer's (2015) interest in wildlife in human-created novel ecosystems and in the way the interests of conservation biologists have been swayed by the appeal of charismatic species and environments. They are broadly in agreement with some of the critiques from geography of dualist approaches to environmental politics identified in this article.

Furthermore, Harvey's and Ollman's relational dialectical approach, with its focus on processes over things, is useful here. Rather than analysing what happens on, say, a small coffee plantation and treating it in isolation the latter is constituted by diverse processes occurring across multiple spatial scales. Climate change, geopolitical arrangements, trends in human coffee consumption, changes in individual farmer preference, national or regional agricultural policy and many other such processes that stretch beyond a specific locality all act to produce a particular type of ecosystem. Indeed, the inherently political implications of understanding ecosystems where human action plays such a major role is one of the reasons why Perfecto and Vandermeer have become interested in agriculture. As Perfecto explains:

> I like to look at this interaction between the humans and the natural system–the social system, the political system, and the natural system–and so if I work in a reserve, some place in the middle of nowhere, there is still some effect that the humans have on that area but it is not as evident…as it is in an agricultural system. (Interview, 22 September 2014)

However, this is not to say that Perfecto, Vandermeer and their colleagues neglect the role played by the many non-human species present in constituting such agro-ecosystems. These different species interact in complex ways. Ecological processes such as mutualism, parasitism, predation and competition are all evident (Vandermeer et al. 2010). Although many species are considered pests of coffee, some also provide autonomous pest control, reducing the need for farmers to apply synthetic pesticides (Vandermeer et al. 2010). But the presence of these species is inextricable from the growing of coffee for humans. Although agriculture (some types of agriculture more than others) is often, for good reasons, seen as having a negative effect on biodiversity, for Perfecto (2016) and colleagues: "agriculture provides an ideal arena to study biodiversity because it is an eminent driver of biodiversity loss, yet the services of species in forms of pest control, nutrient cycling, and pollination translate into benefits to productivity and sustainability".

Perfecto and Vandermeer's work implicitly poses a challenge to the assumption that biodiversity is something that happens where agriculture is absent. They avoid conflating wildlife with wild spaces or wilderness, a dualistic way of dividing up space that geographers have also opposed (see Whatmore and Thorne 1998). They also touch on the question of what might be described as the agency of non-humans in these systems (although they would not necessarily adopt this term), Perfecto describes the research as "trying to understand what all this diversity is *doing* in the agro-ecosystem? What is the function of biodiversity?" (Interview, 22 September 2014).

Conclusion

For Ollman, dialectical thought grasps something about a reality that is constantly in motion. Likewise, dialectical biologists have also seen dynamism as central to their understanding. Levins and Lewontin maintain that they start from the position that the world is fundamentally dynamic: it is stasis that requires explanation; defining their own work in opposition to that of reductionist approaches to biology, they say that the dialectical thinker "regards constancy as the normal condition, to be proven otherwise" (Levins and Lewontin 1985:277). In ecology this means recognising that ecosystems, as we observe them, are not in their final phase but that their composition continues to change over time.[viii] This dynamism is seen as resulting from the actions of the organisms transforming their environments rather than dynamism resulting from factors external to the system such as fires or floods (Preston 2003:54). For Perfecto "organisms change their environment and then are changed by their environment–it's a constant–things are constantly changing" (Interview, 22 September 2014). Inherent to this approach to biology, and to environmental thought, is the notion that socio-natural systems are always open to change and transformation.

Brincat and Gerber (2015) make the case for the political importance of dialectics as an approach predicated on not accepting things as they are. But, they argue that a more naturalistic Marxism ought to be developed particularly in a context of urgent capitalist ecological crises. In the spirit of this appeal, this article addresses the naturalistic Marxism of a small group of biologists. I argue that their work offers a sophisticated understanding of the way living things construct their environments and the role of multiple actors in ecosystems.

The dialectical biology referred to here is also an inherently normative approach. Therefore dialectical thinking can also address some of the problems Kirsch and Mitchell (2004) identify with actor-network theory, that it offers no clear political perspective. Furthermore, highlighting the work of biologists who are influenced by Marxism addresses

Braun's (2015) point that geographers should avoid scientism–an assumption that science "speaks with one voice". Many of the scientists in question have developed their approach while remaining aware that both their own practice as scientists and the systems they study cannot be understood without reference to the context in which they occur. Both the uses to which science is put and, importantly, the content of scientific knowledge, can be seen as expressing a particular ideology.

This way of thinking has challenged orthodoxies within biology and is highly pertinent to current debates among environmental geographers. Nevertheless, dialectics has been under-utilised and often met with outright rejection, especially when accused of introducing problematic binaries between what is social and what is natural and of seeing the production of nature as exclusively human, therefore downplaying the vitality and materiality of non-human actors. In this article I have aimed to add clarity to these ongoing debates, using examples from the biological sciences to show how, contra these criticisms, dialectical thinking can be interpreted in a relational way that sees the production of nature as a more-than-human process. This confirms, as Sheppard (2008) argues, that there is a tradition of dialectical thought concerned with complexity, dynamism and agency, a set of concerns that new/vital materialisms also seek to address. The criticisms of dialectics put forward by some geographers are directed against other geographers rather than against biologists. So invoking biology doesn't necessarily resolve these debates. However, an examination of how dialectics is used in biology demonstrates that it is not necessary for dialectics to neglect non-humans. Therefore, incorporating some of these insights into a Marxist political ecology could further reinvigorate the field through attending to non-human agency.

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References

Begon M, Townsend C and Harper J (2006) *Ecology: From Individuals to Ecosystems* (4th edn). Oxford: Blackwell

Bennett J (2009) *Vibrant Matter: A Political Ecology of Things.* Durham: Duke University Press

Benton T (1991) Biology and social science: Why the return of the repressed should be given a (cautious) welcome. *Sociology* 25(1):1-29

Boyd W, Prudham W S and Schurman R A (2001) Industrial dynamics and the problem of nature. *Society and Natural Resources* 14(7):555-570

Bramwell D (2015) A forest of figs. *Waterfront* 26 November http://canalrivertrustwaterfront.org.uk/culture/a-forest-of-figs (last accessed 16 February 2016)

Braun B (2015) New materialisms and neoliberal natures. *Antipode* 47(1):1-14

Brincat S and Gerber D (2015) The necessity of dialectical naturalism: Marcuse, Bookchin, and dialectics in the midst of ecological crises. *Antipode* 47(4):871-893

Castree N (1996) Birds, mice, and geography: Marxisms and dialectics. *Transactions of the Institute of British Geographers* 21(2):342-362

Castree N (2002) False antitheses? Marxism, nature, and actor-networks. *Antipode* 34(1):111-146

Clark B and York R (2005a) Dialectical nature: Reflections in honour of the twentieth anniversary of Levins and Lewontin's *The Dialectical Biologist. Monthly Review* 57(1):13-22

Clark B and York R (2005b) Dialectical materialism and nature: An alternative to economism and deep ecology. *Organisation and Environment* 18(3):318-337

Connolly W (2013) The "new materialism" and the fragility of things. *Millennium* 41(3):399-412

Coole D (2013) Agentic capacities and capacious historical materialism: Thinking with new materialisms in the political Sciences. *Millennium* 41(3)451-469

Coole D and Frost S (2010) *The New Materialisms: Ontology, Agency, and Politics.* Durham: Duke University Press

Cronon W (1995) The trouble with wilderness, or, Getting back to the wrong nature. In W Cronon (ed) *Uncommon Ground: Rethinking the Human Place in Nature* (pp69-90). New York: W. W. Norton & Co

Dixon D P, Woodward K and Jones J P (2008) On the other hand...dialectics. *Environment and Planning A* 40(11):2549-2561

Ellis E C (2015) Ecology in an Anthropocene biosphere. *Ecological Monographs* 85(3):287-331

Engels F (1947 [1888]) *Ludwig Feuerbach and the End of Classical German Philosophy*. London: Lawrence and Wishart

Foster J B (2000) *Marx's Ecology: Materialism and Nature*. New York: Monthly Review Press

Foster J B (2016) Marxism in the Anthropocene: Dialectical rifts on the Left. *International Critical Thought* 6(3):393-421

Foster J B and Clark B (2016) Marxism and the dialectics of ecology. *Monthly Review* 68(5):1-17

Gardner T A, Barlow J, Chazdon R, Ewers R M, Harvey C A, Peres C A and Sodhi N S (2009) Prospects for tropical forest biodiversity in a human-modified world *Ecology Letters* 12:561-582

Gilbert S F, Sapp J and Tauber A I (2012) A symbiotic view of life: We have never been individuals. *Quarterly Review of Biology* 87(4):325-341

Gregory D (2009) Dialectic(s). In D Gregory, R Johnston, G Pratt, M Watts and S Whatmore (ed) *The Dictionary of Human Geography* (5th edn) (pp157-158). Oxford: Wiley

Grosz E (2011) *Becoming Undone: Darwinian Reflections on Life, Politics, and Art.* Durham: Duke University Press

Haraway D (2008) *When Species Meet.* Minneapolis: University of Minnesota Press

Harvey D (1996) *Justice, Nature, and the Geography of Difference.* Blackwell: Oxford

Hobbs R J, Arico S, Aronson J, Baron J S, Bridgewater P, Cramer V A, Epstein P R, Ewel J J, Klink C A, Lugo A E, Norton D, Ojima D, Richardson D M, Sanderson E W, Valladares F, Vilà M, Zamora R and Zobel M (2006) Novel ecosystems: Theoretical and management aspects of the new ecological world order. *Global Ecology and Biogeography* 15(1):1-7.

Kaika M (2005) *City of Flows: Modernity, Nature, and the City.* New York: Routledge

Kirsch S and Mitchell D (2004) The nature of things: Dead labour, nonhuman actors, and the persistence of Marxism. *Antipode* 36(4):687-705

Latour B (2005) *Reassembling the Social: An Introduction to Actor-Network Theory.* Oxford: Oxford University Press

Levins R and Lewontin R (1985) *The Dialectical Biologist.* Cambridge: Harvard University Press

Levins R and Lewontin R (2007) *Biology Under the Influence: Dialectical Essays on Ecology, Agriculture, and Health.* New York: Monthly Review Press

Lewontin R (1982) Organism and environment. In H C Plotkin (ed) *Learning, Development, and Culture* (pp151-170) New York: John Wiley & Sons

Loftus A (2012) *Everyday Environmentalism: Creating an Urban Political Ecology.* Minneapolis: University of Minnesota Press

Lorimer J (2007) Nonhuman charisma. *Environment and Planning D: Society and Space* 25(5):911-932

Lorimer J (2013) Review – *Everyday Environmentalism: Creating an Urban Political Ecology* by Alex Loftus. *Area* 45(1):123-129

Lorimer J (2015) *Wildlife in the Anthropocene: Conservation After Nature.* Minneapolis: University of Minnesota Press

Lukács G (1971 [1922]) *History and Class Consciousness: Studies in Marxist Dialectics.* London: Merlin

Marx K (1976 [1873]) Afterword to the second German edition. In *id. Capital, Volume I* (pp94-103). London: Penguin

Merrifield A (1993) Place and space: A Lefebvrian reconciliation. *Transactions of the Institute of British Geographers* 18(4):516-531

Moore K (2013) *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, 1945-1975.* Princeton: Princeton University Press

Moore J W (2015) *Capitalism In the Web of Life.* New York: Verso

Odling-Smee F J, Laland K N and Feldman M W (2003) *Niche Construction: The Neglected Process in Evolution.* Princeton: Princeton University Press

Odling-Smee F J, Erwin D H, Palkovacs E P, Feldman M W and Laland K N (2013) Niche construction theory: A practical guide for ecologists. *Quarterly Review of Biology* 88(1):3-28

Ollman B (2003) *Dance of the Dialectic: Steps in Marx's Method.* Chicago: University of Illinois Press

Ollman B (2014) Dialectics and world politics. *Globalizations* 11(5):573-579

Perfecto I (2016) Ivette Perfecto, George Willis Pack Professor, University of Michigan School of Natural Resources and Environment. http://www.snre.umich.edu/research/faculty/ivette_perfecto (last accessed 21 February 2017)

Perfecto I and Vandermeer J (2008) Biodiversity conservation in tropical agroecosystems: A new conservation paradigm. *Annals of the New York Academy of Sciences* 1134:173-200

Preston C J (2003) *Grounding Knowledge: Environmental Philosophy, Epistemology, and Place.* Athens: University of Georgia Press

Robbins P (2007) *Lawn People: How Grasses, Weeds, and Chemicals Make Us Who We Are*. Philadelphia: Temple University Press

Robbins P (2012) *Political Ecology* (2nd edn). Oxford: Wiley-Blackwell

Rose S and Rose H (2010) Darwin and after. *New Left Review* 63:91-113

Sheppard E (2008) Geographic dialectics? *Environment and Planning A* 40(11):2603-2612

Smith N (2008) *Uneven Development: Nature, Capital and the Production of Space* (3rd edn). Athens: University of Georgia Press

Soja E W (1980) The socio-spatial dialectic. *Annals of the Association of American Geographers* 70(2):207-225

Swyngedouw E (2014) Anthropocentric politicization, In K Bradley and J Hedrén (eds) *Green Utopianism: Perspectives, Politics, and Micro-Practices* (pp23-37). New York: Routledge

Tyner J and Inwood J (2014) Violence as fetish: Geography, Marxism, and dialectics. *Progress in Human Geography* 38(6):771-784

Vandermeer J and Perfecto I (2012) Syndromes of production in agriculture: Prospects for social-ecological regime change. *Ecology and Society* 17(4) http://www.ecologyandsociety.org/vol17/iss4/art39/ (last accessed 21 February 2017)

Vandermeer J, Perfecto I and Philpot S (2010) Ecological complexity and pest control in organic coffee production: Uncovering an autonomous ecosystem service. *Bioscience* 60(7):527-537

Whatmore S (1999) Hybrid geographies. In D Massey, J Allen and P Sarre (eds) *Human Geography Today* (pp22-40). Cambridge: Polity

Whatmore S and Thorne L (1998) Wild(er)ness: Reconfiguring the geographies of wildlife. *Transactions of the Institute of British Geographers* 23(4):435-454

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i Although Foster and Moore both refer to dialectics in their work they clearly have strong disagreements (Foster 2016). Space here doesn't allow for more than an acknowledgement of this heated debate between Marxists but I intend to discuss it elsewhere.

ii Castree (2002) is referring in this case to ANT. There are distinctions to be made between ANT and more recent strands of vital materialism but the point that these theories are (sometimes falsely) seen as antithetical to Marxism still stands.

iii Thanks to Stuart Newman for this point.

iv The influence of the idea is itself testament to Lewontin's reputation as an esteemed evolutionary biologist.

v

Lewontin is familiar with Ollman's (2003) book *Dance of the Dialectic* and refers to it in a discussion of abstraction (Levins and Lewontin 2007:150).

vi Ecology is concerned with the way organisms relate to each other and to non-living aspects of their environment while evolutionary biology deals with how species have evolved over long time-scales. The two have sometimes been considered as distinct while niche construction claims to integrate the two.

vii Strictly speaking a novel ecosystem is established by humans but does not require continued human influence for its maintenance. The term is used more loosely here for systems where human activity continues to play a dominant role.

viii Thanks to Joop van Lenteren for this point.